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PLATE REVISE.

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REVIEW OF RECENT ADVANCES IN OUR KNOWLEDGE OF THE ANATOMY AND PHYSIOLOGY OF THE NERVOUS SYSTEM.

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Gentlemen:—The department of medicine which I shall teach is that of neurology, or that branch of medical science which especially relates to the mind and nervous system; my lectures will, therefore, embrace all the various morbid conditions of the brain, spinal cord and peripheral nerves as well as insanity.

In presenting this subject I shall bear in mind that we are studying the most difficult branch of medicine, so in order to render it plain and practical, as well as easy of comprehension, I shall purposely rob it of its many technicalities and present it in as simple and common-place phraseology as possible, believing this to be of far more practical importance to you at this time than an extensive and intricate discussion of the questions under consideration.

It seems impossible for some professors and teachers to leave the maze of hypothetical medical lore and descend to the more essential elementary plane of facts which come within the comprehension of every thoughtful student, and which indeed are the necessary equipment of every person seeking the degree of *Doctor of Medicine*. I shall try to avoid this error by presenting to you primarily only the more essential elementary principles of our subject with a degree of plainness which will enable you to receive them with benefit, for after all it is not so much what you *hear* as what you *absorb* and *store away for future use* that profits you the most.

For a proper understanding of neurological subjects a general knowledge of the anatomy and physiology of the nervous system is absolutely essential; I shall, therefore, take occasion at the outset to review in detail some of the more important anatomical and physiological facts connected with the nervous system.

In alluding to this I am aware that there is a prevalent opinion among students and even practitioners of medicine that the anatomy and physiology of the nervous system is far too complex a study for them to master and is only of interest and importance to those who are willing to devote their sole time and attention to it. This is not so. A thorough mastery of the subject makes clinical neurology comparatively easy and in fact reduces much of it simply to a matter of logical deduction.

Our study of the nervous system and its diseases naturally divides itself into a consideration of its normal anatomy, physiology, symptomatology, etiology, pathology, diagnosis, prognosis, treatment and prophylaxis.

We commence, therefore, by a brief review of the more salient facts concerning its anatomy and physiology.

DEFINITION.—A good working definition of the nervous system and one which has the advantage of being both brief and practical is that furnished by Dalton; it is this:

"The nervous system is an apparatus of inter-communicating fibres and cells disseminated throughout the body and standing in anatomical connection with the various organs of the animal system."

If we consider it as a unit we may say that it is that organ of the body by which the conditions of the outer world are perceived, by which its relations are appreciated and by which the actions of the individual towards it are regulated, while it also takes cognizance of the various conditions of the several parts of the body itself, in some respects controlling them, in others being in turn by them controlled.

General Function.—Its general function is to associate the different parts of the body in such a manner that a stimulus applied to one organ excites to action that of another.

As an illustration of this we find that when food is introduced into the mouth it excites the flow of saliva from the parotid gland and after being mixed with this it is forced into the stomach where it again excites to action the various glands which pour out their secretion, and from thence it passes to the intestines where it gives rise to that wonderful mechanism we term the peristaltic action of the bowel.

From this we learn that every organ of the body is subservient in the manifestation of its functional activity to influences from other parts of a structure different from its own. Hence, the normal physiological stimulus which calls into action the various organs of the body is not *direct* but *indirect* in its operation and this communication is established through the medium of the nervous system.

It is evident, therefore, that the the nervous system is not, as some erroneously suppose, simply an appendage to the rest of the body, but it is an integral portion of every part of it, not only having special organs of its own, but also entering deeply into the formation of every other organ ; indeed the perfection of the animal organization depends largely upon the general development of the nervous system and by virtue of the immense preponderance of gray cerebral nerve tissue *man* stands immeasurably above all other created beings.

Its Composition.—The nervous system is composed of two classes of elements : (1) nervous tissue elements proper ; (2) non-nervous tissue elements.

The former consists of the fibres, cells, and neuroglia, which together form the nerves. The latter comprise the connective tissue, blood vessels, lymphatics and epithelium. These various elements when united form two great systems, viz : (1) A central nervous system ; (2) a peripheral system.

Both of these, however, when taken collectively constitute a series of organs consisting of (1) the cerebro spinal center or axis, (2) ganglia, (3) nerves, (4) and certain modifications of the peripheral terminations of nerves, technically known as end organs. These latter constitute the organs of the external senses.

Of these various organs, (*a*) the central nervous system includes the cerebro-spinal center or axis which consists of the brain and spinal cord, the nerve centers of which are made up of white and gray matter inclosed in membranes termed meninges.

(*b*) The peripheral nervous system embraces the remainder, viz : the ganglia, nerves and end organs. It is usually described as consisting of two parts, (I) the cerebro-spinal system of nerves, and (II) the sympathetic system of nerves. The former being distributed mainly to the muscles and skin, the latter to the viscera and blood vessels. Both portions, however, are alike made up of nerve fibres derived from and dependent on the brain and spinal cord and both connected in their course with peripheral ganglia and end organs.

Structure.—In its structure the nervous system presents the most striking example of simplicity and wisdom combined.

It consists of three kinds of tissues each of which differs in appearance, structure and physiological endowment. (*a*) One of these is represented

by the white substance which may be disposed in layers, masses or tracts and is composed of nerve fibres alone. (*b*) Another constitutes the gray substance or vesicular matter which contains in addition to fibres, cells and interstitial matter. (*c*) The remaining one is known as the gelatinous tissue and is sometimes termed the fibres of Remak. It differs essentially from the other two, but as its histological elements are still held in dispute it may be regarded as a supporting structure. Each of these elements may now with profit be reviewed in detail, and first of all the nervous tissue elements proper, viz: the fibres, cells and neuroglia, after which the non-nervous elements will occupy our attention.

Nerve Fibres.—The nerve fibres constituting the white matter are cylindrical tubes or filaments arranged in bundles or tracts which for the most part run in a direction parallel to each other. Their size and diameter varies considerably in different situations from $\frac{1}{2500}$ to $\frac{1}{1700}$ of an inch according to Flint. The largest of them are found in the peripheral trunks and branches of nerves.

Varieties.—They are divided into two principal varieties, viz: (1) Medullated and (2) non-medullated. The former in their most complete form consist of three elements, viz: (1) an external tubular sheath, (2) medullary layer or white substance of Schwann, (3) axis cylinder. The first is the insulating envelope of a nerve fibre, the second consists of an oleaginous substance known as myelin, and the third the conducting element. These medullated nerve fibres make up the great bulk of the white substance of the cerebro-spinal system. In their external sheath nuclei are found between it and the myelin. While the white substance of Schwann presents at regular intervals along its course small imperfect constrictions termed Nodes of Ranvier, besides these are other imperfect divisions or constrictions of the white substance, and these are more numerous than the nodes and are called incisions of Schmidt or lines of Frohmann. The interval between any two nodes is termed an internode. The functions of these anatomical elements are important, as by the nodes the almost liquid myelin is kept evenly distributed along the course of a nerve fibre, while the incisions of Schmidt permits nutrient material to reach the axis cylinder.

Non-Medullated Nerve Fibres.—The non-medullated fibres, or fibres of Remak, are composed of gelatinous tissue. These fibres are destitute of the white substance of Schwann. They constitute chiefly the sympathetic system of nerves. They are absent in all the nerves of special sense except the olfactory, which nerve appears to contain no other fibres. They are said to be grayish and faintly striated. Flint seems to make a distinction between the non-medullary fibres and the gelatinous, but Dana regards them as modifications of the same.

It is well to remember, however, that anatomists differ in their opinions regarding these fibres, as many think they are elements of connective tissue and consequently not endowed with the characteristic properties of nerves, while others think they have all the essential properties of nerve fibres but possess distinct functions of their own.

Nerve Cells.—In studying the nerve cells we must first understand thoroughly the character of the

Gray Substance.—The characteristic anatomical element of the gray substance is the nerve cells of which there are several varieties, but for all practical purposes the (1) bipolar and the (2) multipolar are the most important for you to study.

The bipolar cells are found in the ganglia and posterior roots of spinal nerves. They are characterized by sending out two prolongations.

Multipolar cells are irregular in shape and size and are marked by numerous prolongations. These prolongations are simply extensions of cellular substance pushed out, as it were, from their centers. They serve as connecting links between the fibre and cell.

The nerve cells act as centers in which nervous impressions are received through the afferent nerve fibres and from which a stimulus is given off and transferred by the efferent nerve fibres to the various organs of the body. The general function of nerve cells may, therefore, be said to be the conversion of impressions into impulses. The nature of this change or its wonderful mechanism is still unknown to us but it constitutes the reflex function of the nervous system.

General Uses of Fibres and Cells.—From this then we learn that the fibres and cells make up the great bulk of the nervous appartus and their harmonious correllation is essential for all vital processes. To illustrate their several uses we may liken the nerve fibres to telegraph wires stretched between the brain, spinal cord, muscles, skin and all the organs of the body. While the nerve cells would represent the various offices of a complex telegraph system with the brain as the chief or central office where messages were being constantly recieved and dispatched, every message sent out would be more or less directly the result of some message received. So it is with the nerve cells or centers. We are constantly in receipt of messages from the organs of sight, hearing, touch, taste, smell and other organs, which are conveyed to and from these by means of the various nerve fibres distributed to them. Any injury to any of these fibres in any part of their course would necessarily cause a corresponding impairment at headquarters. The practical application of these facts enable us to understand much concerning the effects of pathological lesions.

Termination of Nerves.—For a long time the termination of nerves of voluntary muscles was a question of great uncertainty, but within the last few years the elaborate researches of French and German anatomists have been so accurately described that the question of the mode of connection between the anatomical elements conducting stimulus to the muscles and the contractile elements of the muscles themselves may be considered as definitely settled.

Rouget's investigations published in 1862, prove that the motor nerve fibres terminate by a blending of the external tubular sheath with the sarcolemma. The medullary layer ending abruptly at the point where the axis cylinder blends with the primitive muscular fibrilla. In the cutaneous surface the motor nerves terminate by forming plexuses.

The sensory fibres, on the other hand, terminate in one of three ways by means of corpuscles named in different situations as follows:

(1) The Pacinian bodies found in the subcutaneous layers of hands and feet and therefore not connected with tactile sensation.

(2) The tactile corpuscles which implies that they subserve the tactile sensation.

(3) The end bulbs of Krause found in the eye, mouth, etc.

As a general statement then, we may say that the sensory nerve fibres end peripherally as plexuses in these end organs, while their central terminations are not as yet well understood. While the motor fibres end centrally in either the gray substance of the spinal cord or cortex of brain.

Neuroglia.—The cells and fibres are supported in their respective positions by a connective tissue matrix known as the neuroglia. It is made up of cells termed *deiter or spider cells.* They differ in shape and size but not general characteristics. It also contains finely ramified fibrils which are connected with the bloodvessels. In inflammatory processes these cells multiply,

swell up and assist in carrying off the irritating products and for this worthy function they have received the name of *scavenger cells.*

We have reviewed in detail the essential points concerniug the nervous tissue elements proper, we now turn our attention to a very brief notice of the non-nervous tissue elements.

Non-Nervous Tissue Elements.—The accessory anatomical elements of the nervous system constitute the non-nervous element. They consist of the blood vessels, lymphatics, epithelium and connective tissue. All of these are found in the neuroglia.

The arteries serve to bring fresh oxygenated blood; the veins remove the exhausted, impure blood; the lymphatics carry off the surplus fluids and other matters formed during the act of nutrition, while the connective tissue supports each of the various elements in their respective positions.

We have already seen that the nerves are channels or organs of communication and serve as connecting links between the brain, spinal cord, muscles, glands, skin, mucous membranes and other organs in which they terminate. Any excitation at either end of them produces an impulse corresponding to the sensation received. These differences in effects produced by the various stimuli or irritants to nerves has led to their division into two great classes, viz: (I) Afferent nerves and (II) Efferent nerves. Those which transmit impulses from the peripheral organs to the central ones are termed afferent nerves and the stimulus which they convey is termed its centripetal force. While those which transmit impulses from the central organs to the periphery are termed efferent nerves and the stimulus which they convey is termed its centrifugal force. The old division of nerves into motor and sensory is not sufficiently correct, for we know that there are many outgoing nerves that are not motor in function. A much better division is that of afferent and efferent. As a rule both kinds of fibres are associated in the same nervous bundle, but their effects are entirely different. No essential distinction, however, has so far been discoverable in their anatomical structures but to all intents and purposes they seem completely identical.

The immediate effect of division or injury to a nerve fibre causes a suspension or loss of its physiological function. If it be separated from the cell of its central connection degeneration or atrophy ensues. Nerves may regenerate after injury but the time required for this varies considerably.

Spinal Cord.—The nerves of the trunk and limbs are connected with a long rod of nervous matter termed the spinal cord, which again unites them to the brain. The cord is made up of white and gray matter, the former being the most external and is imperfectly divided in the median line into two lateral halves by the anterior and posterior fissures. Each half is composed of white and gray matter, the former being the most external and may be divided into three primary divisions, viz: (1) anterior, (2) lateral and (3) posterior columns. Each of these are again subdivided into several tracts, the study of which together with their special functions constitute one of the most difficult problems in neurological science. One of them is said to be the tract which conveys the sensations of pain, another varying degrees of temperature, a third that of muscular sense, a fourth that of tactile sensation, while still others represent the tracts of voluntary motion. Now it is not my intention to enlarge on these more fully at the present time, but will do so at the proper time, suffice it to say that the anterior column is motor in character, the posterior sensory, and the lateral has a mixed function.

The gray matter of the cord is composed of cells and minute fibres. The cells in the anterior portion are much larger than those found in the posterior. These large cells are connected with the motor nerves which supply the muscular system and seem to possess a trophic function, while the smaller ones are as-

sociated with the sensory nerves. The cells are arranged in groups, which in size and number differ in different situations. From either side of the spinal cord in successive pairs may be seen the spinal nerves which are distributed to the muscles and which have their central connections in the spinal cord and again are continued upwards by the motor tracts of fibres in the spinal cord to different parts of the brain. The vital activities of the nervous system may thus be seen in the phenomena of mind in muscular action, in the various sensations, in the secretions of glands, in the control of blood vessels, in varying degrees of temperature, in visceral action as well as modifications of nutrition.

The correllation of all these various activities therefore may be said to constitute the *functions* of the nervous system, and the principal agents which are instrumental in operating their special forces are three, viz: (1) the nerve fibre, (2) the nerve cell and (3) the end organs.

The various mechanisms are therefore subject to classification as follows:

The motor mechanism or functions.
The sensory " " "
The reflex " " "
The trophic " " "
The secretory " " "
The visceral " " "
The mental or psychical "

In the working of all of these the cell is the agent which generates the nerve force, while the fibre distributes it, at the same time the end organs serve as a receptacles for external stimuli.

Now the disorder of any one of these functions produces a train of symptoms which receives a name according to its character and class. Indeed it may be said that *symptoms are the expression of some derangement of function*, consequently we may classify symptoms of the morbid conditions pertaining to the nervous system under the same headings. Your ability to detect diseased conditions of the nervous system depends entirely on your knowledge of its functions and the character of the symptoms which their derangement produces, for it may be said in a general way that symptoms indicate to you the seat of disease, while its nature and character is determined by their mode of onset and other points connected with the history of the case in question, and these constitute two of the chief points in diagnosis.

In conclusion, then I trust that you will understand that the sympathetic system governs the functions of nutrition, growth, reproduction, and all movements which are purely *involuntary* in character. While the cerebro spinal system governs all movements of animal life, which includes motion, sensation, intellection, special senses, and indeed all acts which are purely *voluntary* in character.

In health we find the correllation of both these forces in harmony, and when from any cause they are interfered with, disease results.

The acts which are under control of the sympathetic system are the involuntary, and these specific functions are performed by us unconsciously, receiving their source of inervation principally from the spinal cord while the voluntary acts of life are governed and controlled by the cerebro-spinal system which receives its source of inervation chiefly from the cells of the cerebral cortex and as this is the seat of all conscious mental action, all conscious acts are referred and find a residence here.

We have thus surveyed in a general way the principal, anatomical and physiological facts concerning the cerebro-spinal architecture of the nervous system, and in my next lecture I hope to review more in detail some of the most important points connected with the brain and spinal cord in health and disease.